GAMETOGENESIS

Dr. Mazin Ahmed
MBBS, M.Sc.
Clinical anatomy

Gametogenesis

- The creation of highly specialized sex cells through a process called MEIOSIS

MEIOSIS

- The process where one diploid germ cells divides in order to create either 1 or 4 haploid cells (23 chromosomes).

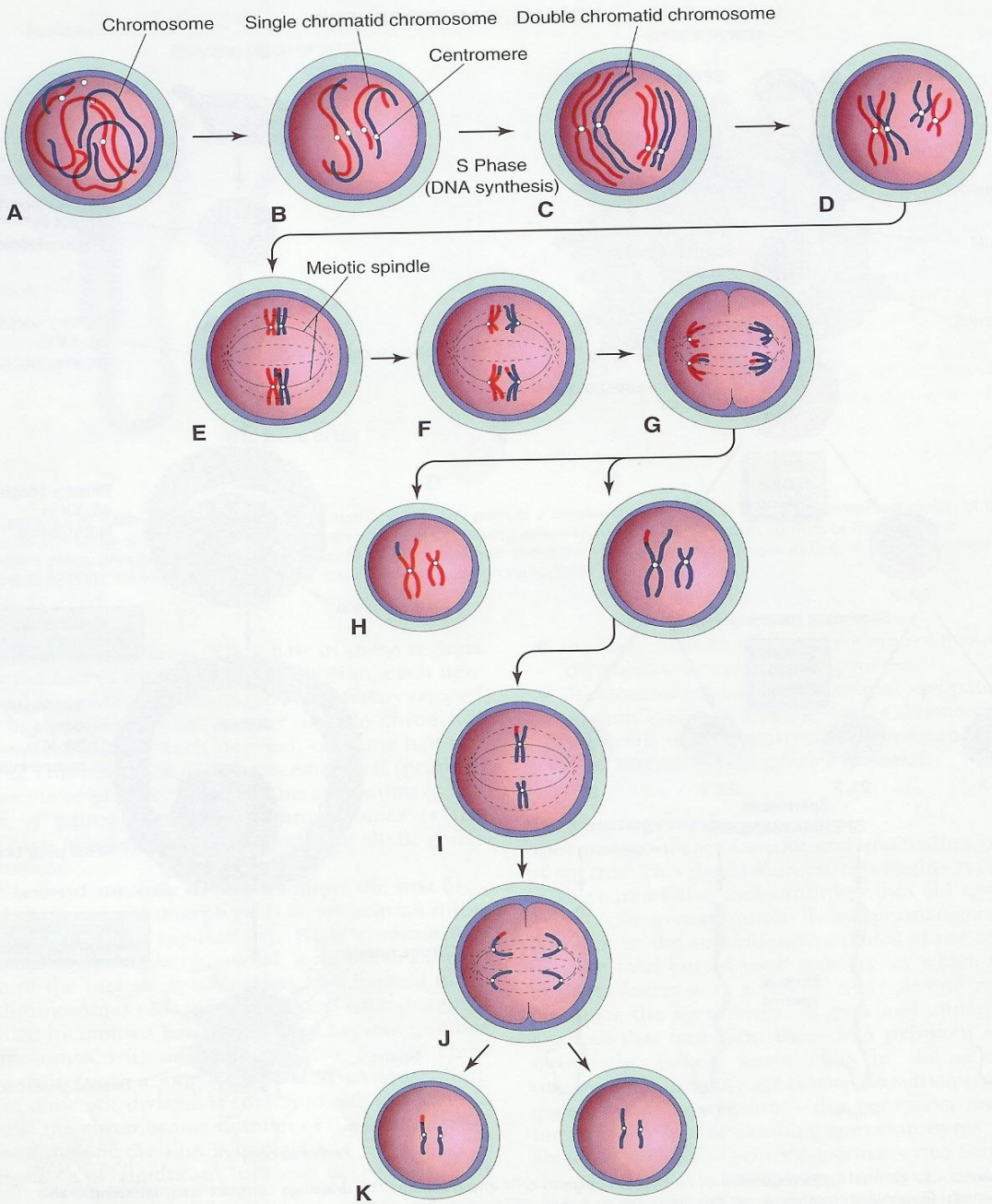


Figure 2 – 6. Diagrammatic representation of meiosis. Two chromosome pairs are shown. *A* to *D*, Stages of prophase of the first meiotic division. The homologous chromosomes approach each other and pair; each member of the pair consists of two

Gametogenesis

means formation of gametes (Sperm & Ova).

Spermatogenesis

Means formation of sperm ; male gametes.

Oogenesis

Means formation of ovum ; female gametes.

Sperm and ovum are highly specialized sex cells.

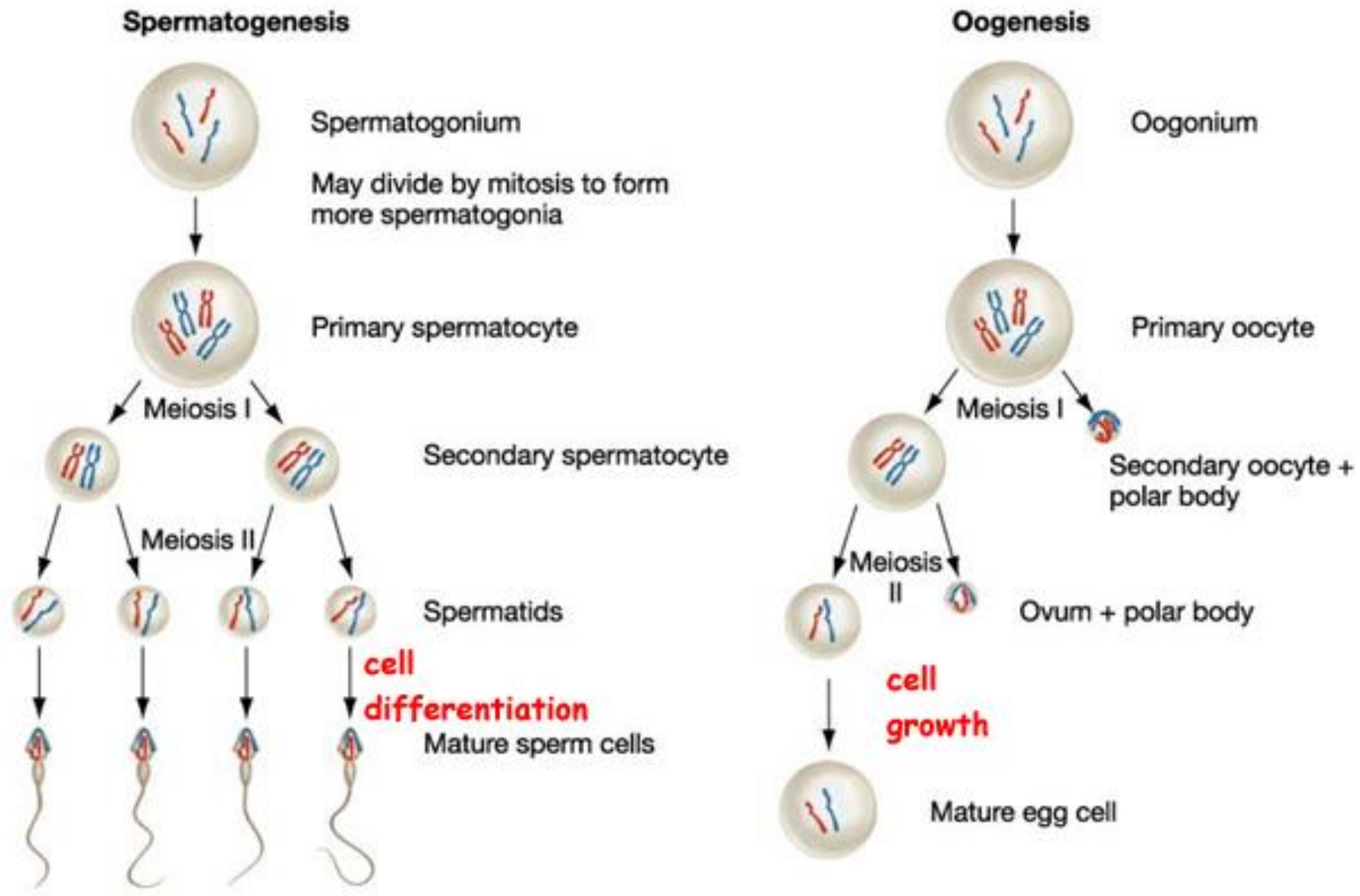
Both types possess three main phases:

1. Period of multiplication: The primordial germ cells multiply by mitotic cell division giving rise to oogonia in case of females and spermatogonia in case of males.

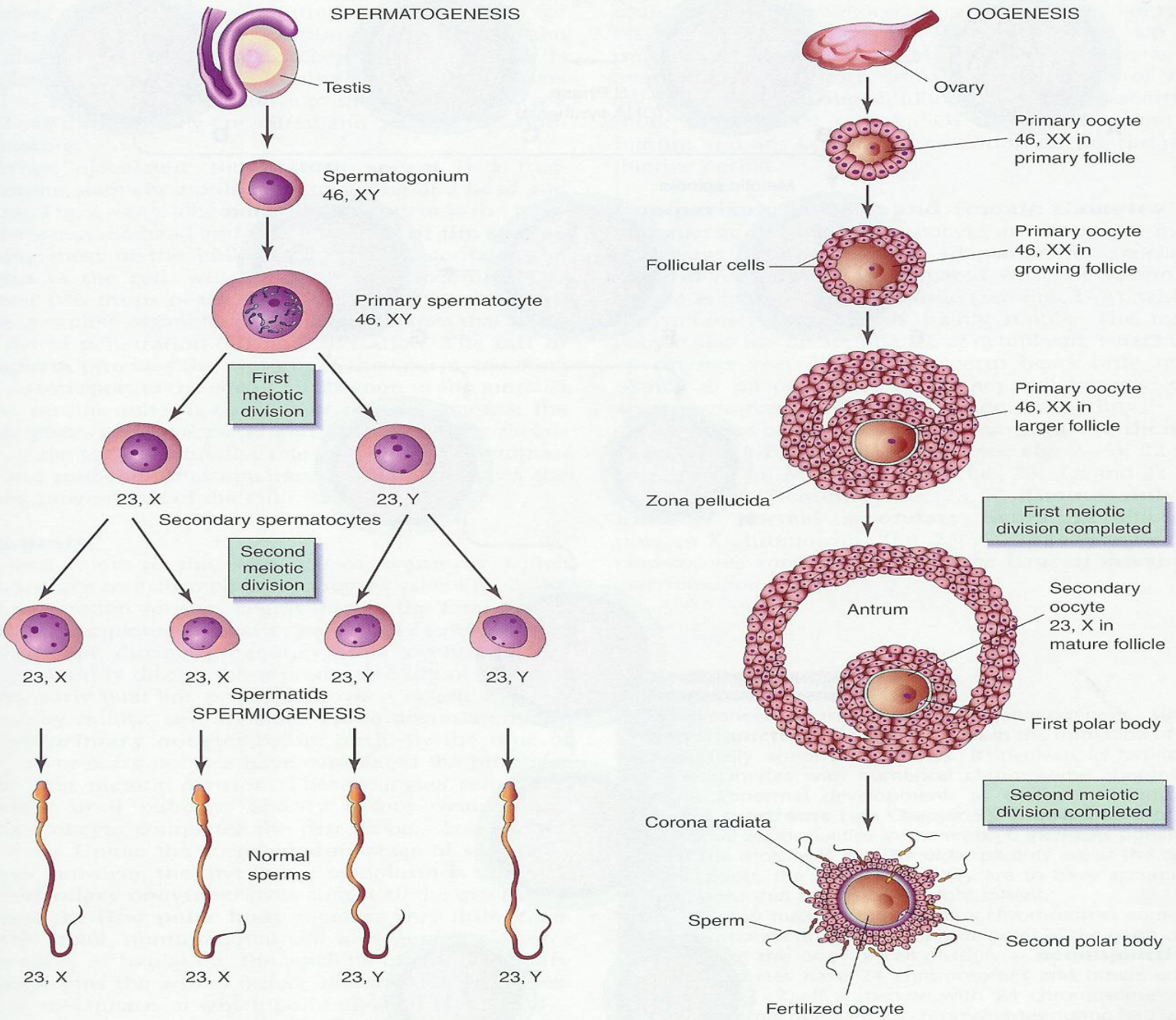
2. Period of growth: During these phase both oogonia (female gamete) and spermatogonia (male gamete)
   grow into primary oocyte or primary spermatocyte.

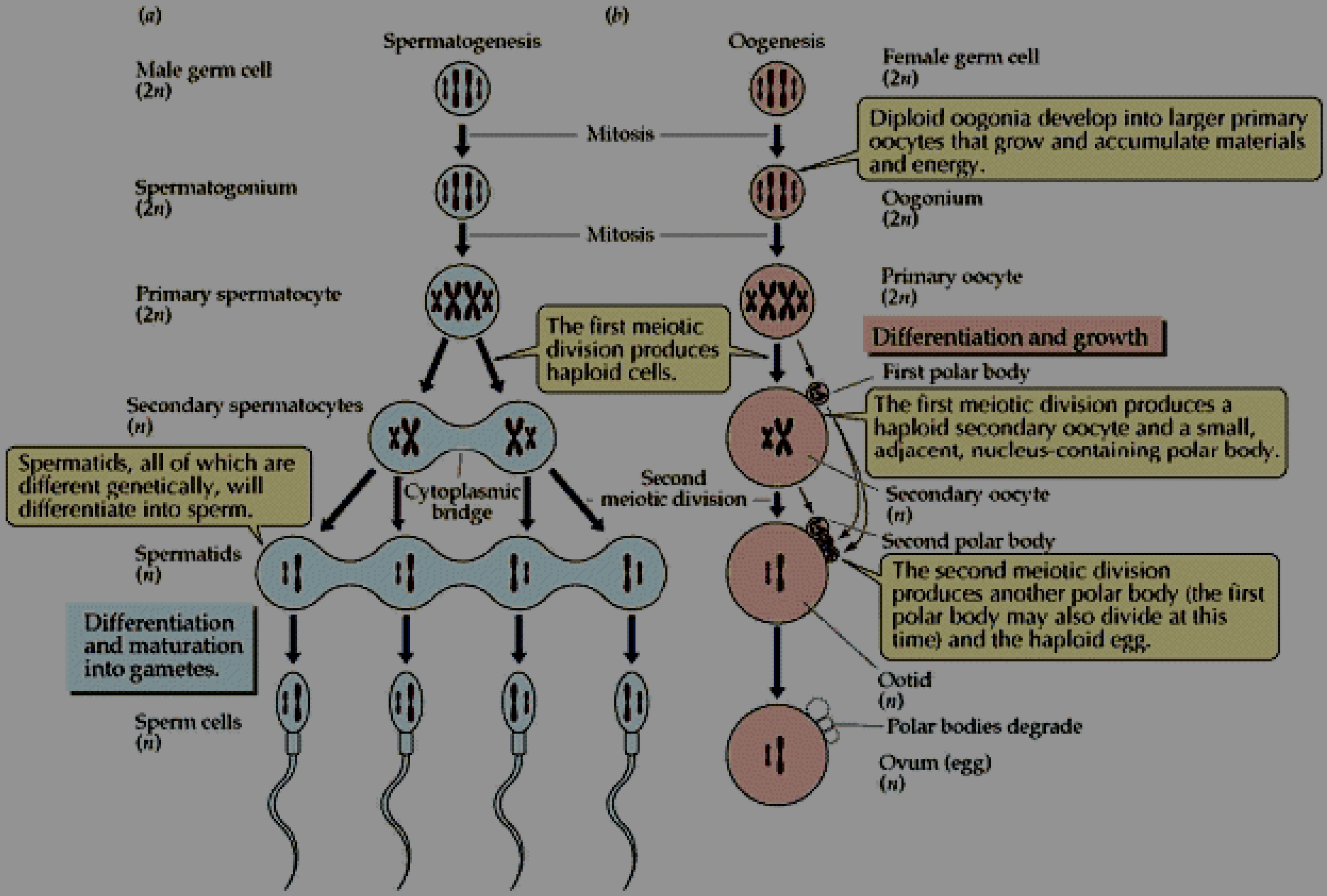
1. Period of maturation: In case of female, the primary oocyte undergoes two meiotic cell division, the first gives rise to secondary oocyte and primary polar body. The secondary undergoes second meiotic division giving rise to mature ova and secondary polar body (mature ova leach oogonia).

   In case of male, each primary spermatocyte divides meiotically into secondary spermatocytes and intern to spermatid (4 spermatid l each primary spermatocyte).

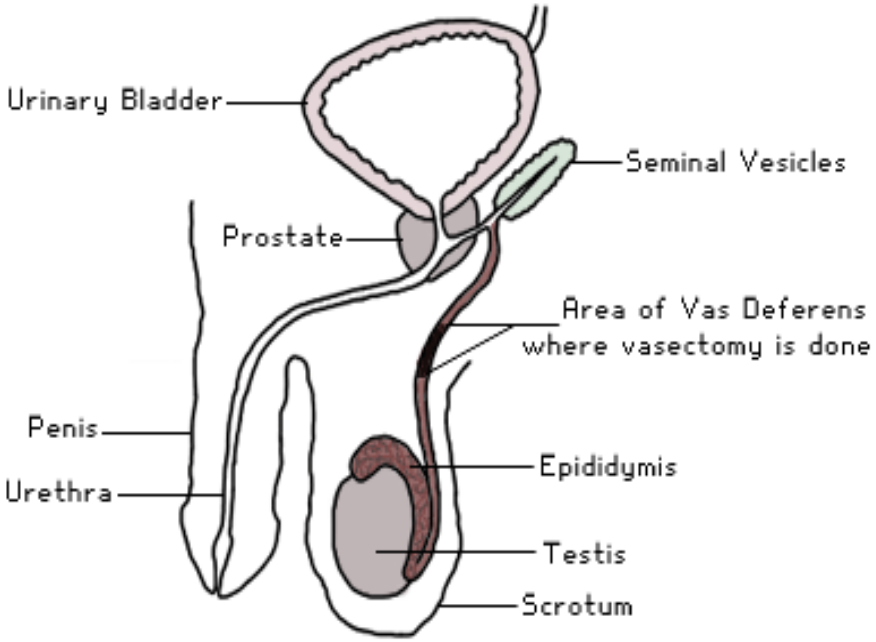

Spermatogenesis
Spermatogonium
May divide by mitosis to form more spermatogonia
Primary spermatocyte
Meiosis I
Secondary spermatocyte
Meiosis II
Spermatids
cell differentiation
Mature sperm cells
Oogenesis
Oogonium
Primary oocyte
Meiosis I
Secondary oocyte + polar body
Meiosis II
Ovum + polar body
cell growth
Mature egg cell

NORMAL GAMETOGENESIS




(a)
Spermatogenesis
Male germ cell
(2n)
Mitosis
Spermatogonium
(2n)
Mitosis
Primary spermatocyte
(2n)
The first meiotic division produces haploid cells.
Secondary spermatocytes
(n)
Cytoplasmic bridge
Spermatids, all of which are different genetically, will differentiate into sperm.
Spermatids
(n)
Differentiation and maturation into gametes.
Sperm cells
(n)
(b)
Oogenesis
Female germ cell
(2n)
Diploid oogonia develop into larger primary oocytes that grow and accumulate materials and energy.
Oogonium
(2n)
Primary oocyte
(2n)
Differentiation and growth
First polar body
The first meiotic division produces a haploid secondary oocyte and a small, adjacent, nucleus-containing polar body.
Second meiotic division
Secondary oocyte
(n)
Second polar body
The second meiotic division produces another polar body (the first polar body may also divide at this time) and the haploid egg.
Ootid
(n)
Polar bodies degrade
Ovum (egg)
(n)

Male Genital System



Male Reproductive System

Overview of Gross Anatomy of Male Reproductive System:

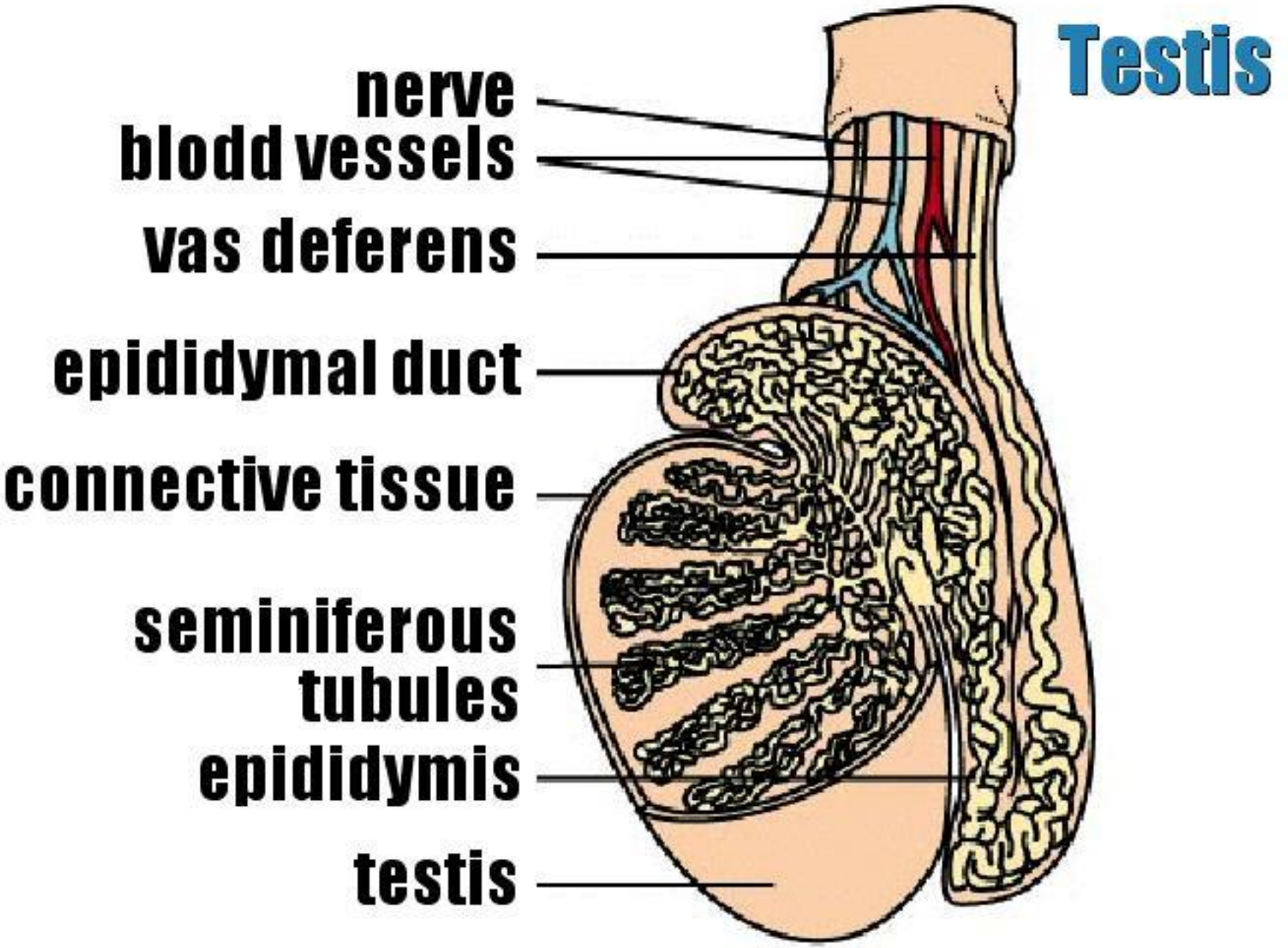
- Testis
  - Male sex gland, Located in the Scrotum.
  - Produce Sperm and Androgens.
  - Have also the interstitial cells (leydeg cells) that produce male sex hormone (testosterone)
  - Seminiferous tubules is the structural unit of testes., it have the developmental phases of sperms in addition to Sertoli cells.
- Epididymis
  - Sperm Storage
  - Complete of sperm maturation.
- Vas Deferens

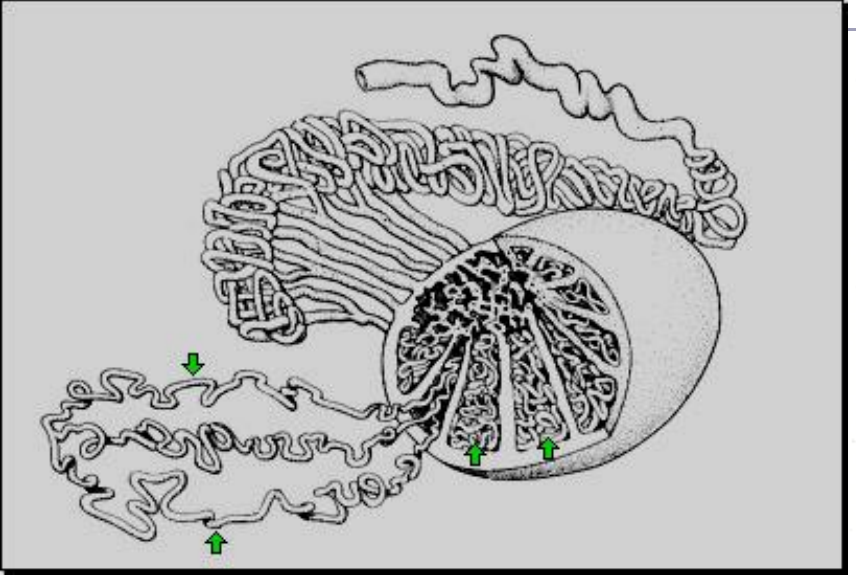
- Duct that transports the Sperm from the Scrotum to the Prostate Gland
  - Seminal Vessicle
- Secrets Fluid, rich in Fructose, to Semen

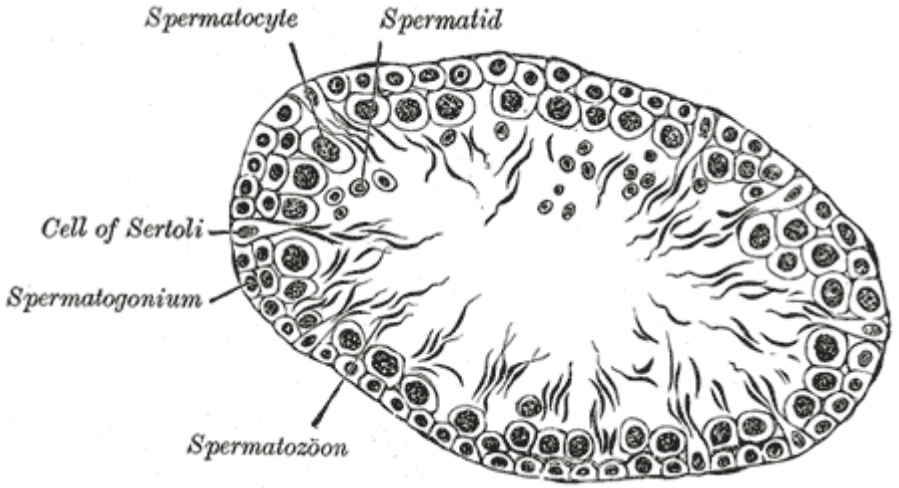
- Prostate Gland (Ejaculatory Duct)

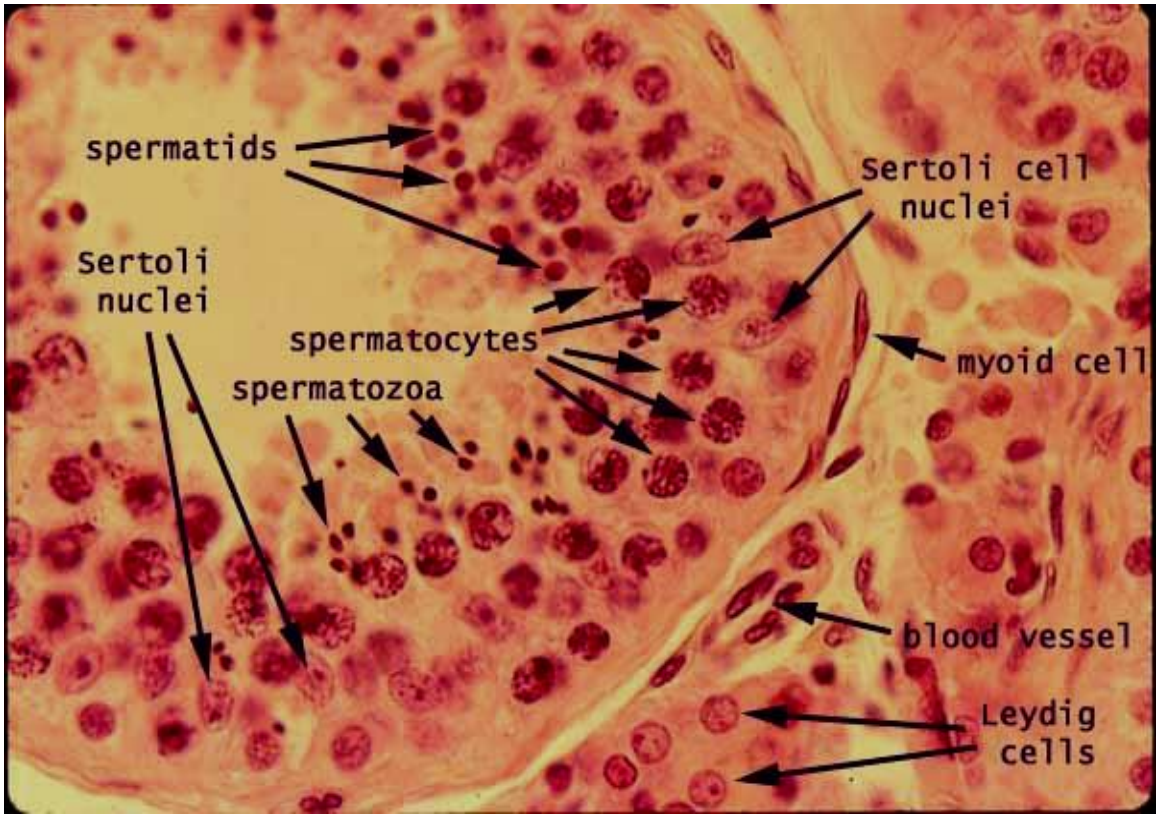
- Contributes Milky Alkaline Fluid that assists Sperm Activation
  - Cowpers Gland [Bilbourethral Gland]
- Contributes Mucus to Semen
  - Urethra (Penis)
- Organ of Copulation

Testis


nerve
blodd vessels
vas deferens
epididymal duct
connective tissue
seminiferous tubules
epididymis
testis




Spermatocyte
Spermatid
Cell of Sertoli
Spermatogonium
Spermatozoön

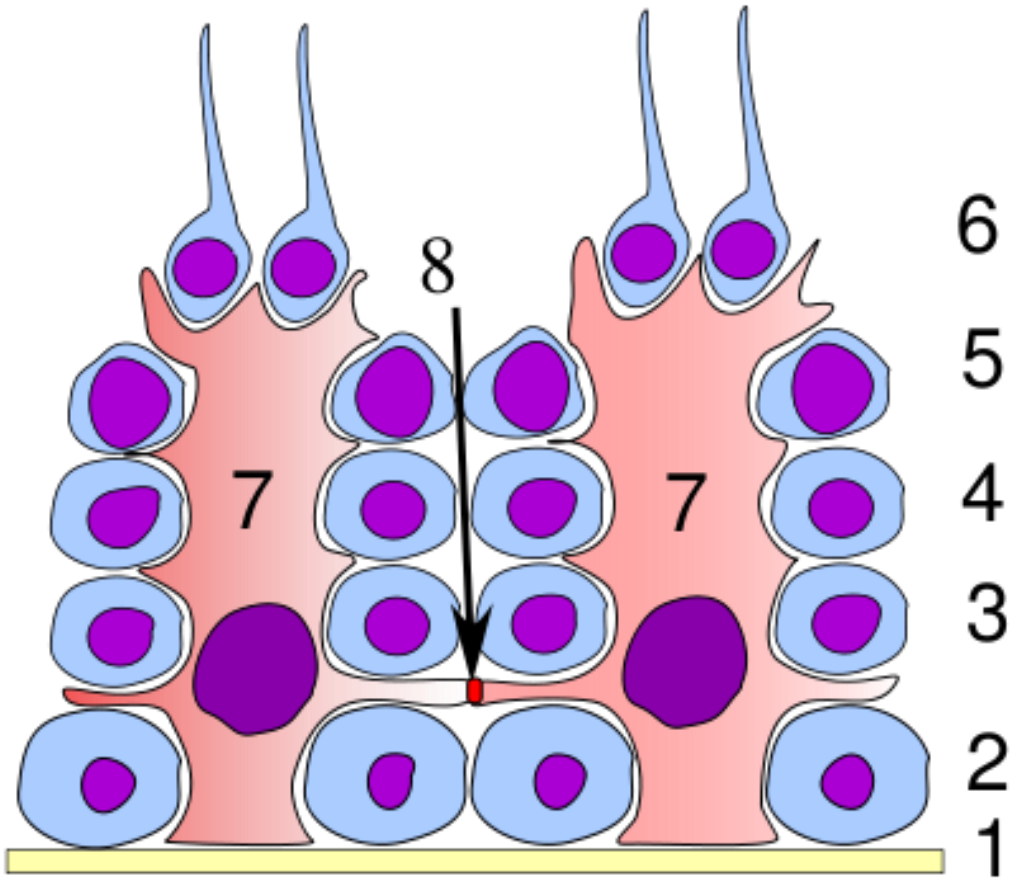

spermatids
Sertoli cell nuclei
Sertoli nuclei
spermatocytes
myoid cell
spermatozoa
blood vessel
Leydig cells

Sertoli Cells

- At all stages of differentiation, the spermatogenic cells are in close contact with Sertoli cells which are provide structural and metabolic support to the developing sperm cells .
- A single Sertoli cell extends from the basement membrane to the lumen of the seminiferous tubule.

- Sertoli cells serve a number of functions during spermatogenesis like providing the cells with nourishment and molecular signals. ‹ they support the developing gametes in the following ways:

1. **Maintain the environment necessary for development and maturation via the blood-testis barrier.**
2. **Secrete substances initiating meiosis .**
3. **Secrete supporting testicular fluid.**
4. **Secrete androgen-binding protein, which concentrates testosterone in close proximity to the developing gametes .**
5. **Secrete hormones effecting pituitary gland control of spermatogenesis, particularly the polypeptide hormone, inhibin.**
6. **Phagocytose residual cytoplasm left over from spermiogenesis.**


8
7
7
6
5
4
3
2
1

SPERMATOGENESIS

- The process of development of spermatids from the male primordial germ cells and their differentiation into spermatozoa.
- Under stimulation anterior pituitary gonadotropic hormones.
- PROCESS :

1. The Primordial germ cells develop into spermatogonia.

There are two types of spermatogonia:

Type A: that divide by mitosis to provide a continuous reserve of type B.

Type B: that enter spermatogenesis.

2.This occurs after puberty, and they remain in the wall of the Seminiferous Tubule .

3. Spermatogonia form primary spermatocytes.

4.They remain in the prophase of 1st meiotic division for 16 days.

5. Each contains 22 pairs of autosomes and one pair of sex chromosome XY.

6.Then divides into two secondary spermatocytes. (Meiotic div. completed).

7.Each secondary spermatocyte has equal cromosomes.(22+X) or (22+Y).

8.Each of these divides again(2nd meiotic div), thus forming 4 Spermatids.

9.Each containing equal cytoplasm and, HAPLOID chromosomes….

TWO with 23X & TWO with 23Y

Spermiogenesis

- Spermatids undergo morphological changes to form spermatozoa.

Spermiogenesis

- It is the last phase of spermatogenesis.
- The rounded spermatid is transformed into elongated sperm.
- Note the loss of cytoplasm, development of the tail, and formation of acrosome, which is derived from Golgi region of spermatid.
- Acrosome contains enzymes that are released at the biginning of fertilization to help sperm in penetrating corona radiata & zona pellucida surrounding secondary oocyte.

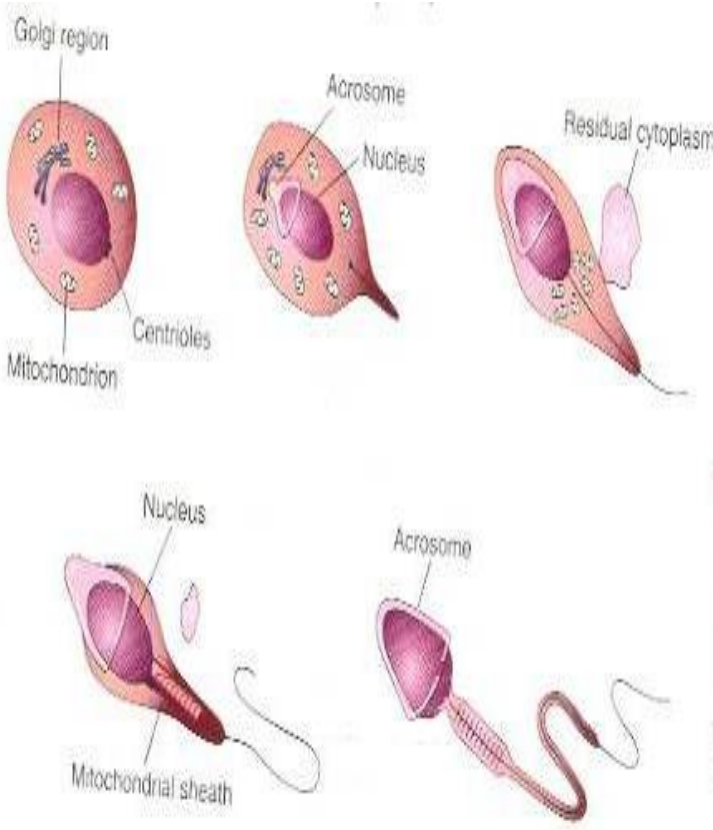
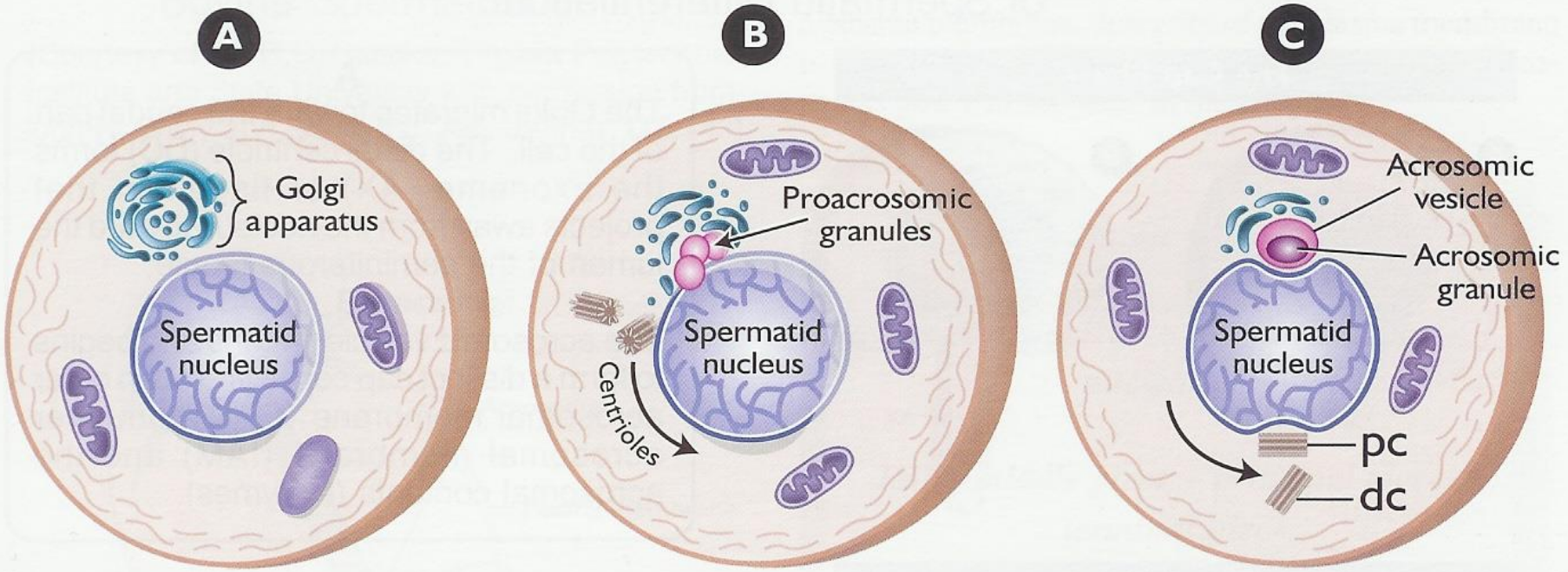


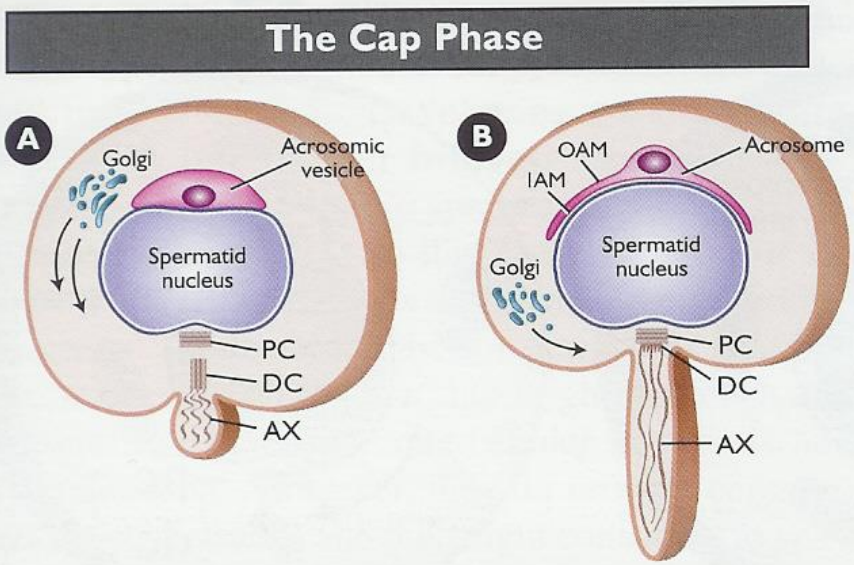
Figure 10-6. The Golgi Phase of Spermatid Differentiation



The newly formed spermatid is almost perfectly spherical and has a well developed Golgi apparatus.

Small vesicles of the Golgi fuse, giving rise to larger secretory granules called pro-acrosomic granules. The centrioles start to migrate to a position beneath the nucleus that is opposite the acrosomic vesicle.

Vesicle fusion continues until a large acrosomic vesicle is formed that contains a dense acrosomic granule. The proximal centriole (PC) will give rise to the attachment point of the tail. The distal centriole (DC) will give rise to the developing axoneme (central portion of the tail) inside the cytoplasm of the spermatid.

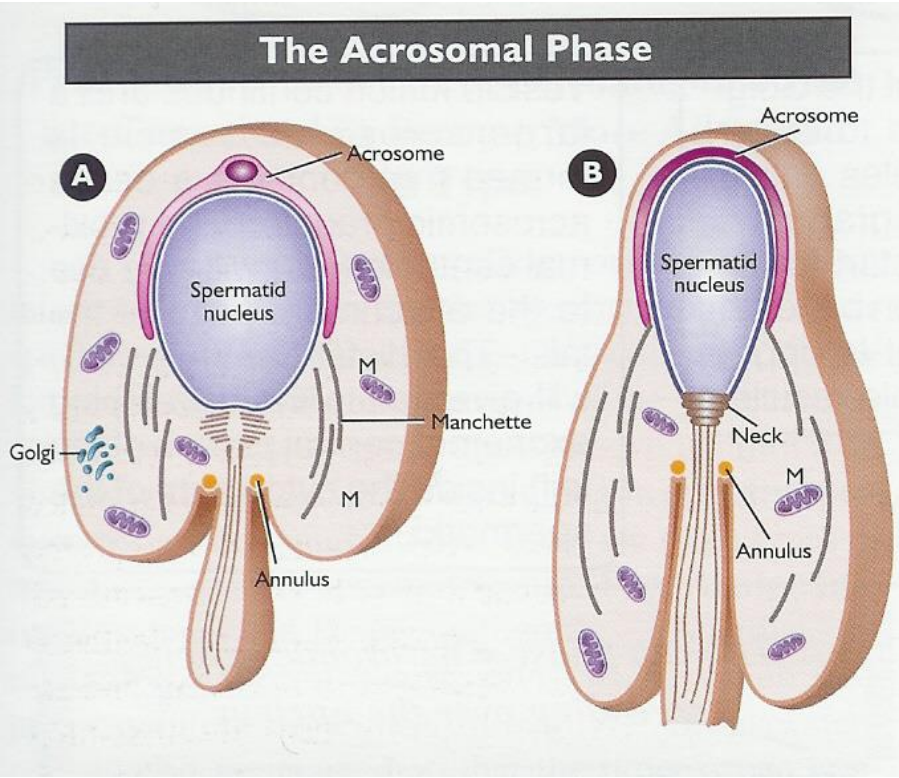


A

The Golgi migrates toward the caudal part of the cell. The distal centriole (DC) forms the axoneme (AX) or flagellum that projects away from the nucleus toward the lumen of the seminiferous tubule.

B

The acrosomic vesicle flattens and begins to form a distinct cap consisting of an outer acrosomal membrane (OAM), an inner acrosomal membrane (IAM) and the acrosomal contents (enzymes).

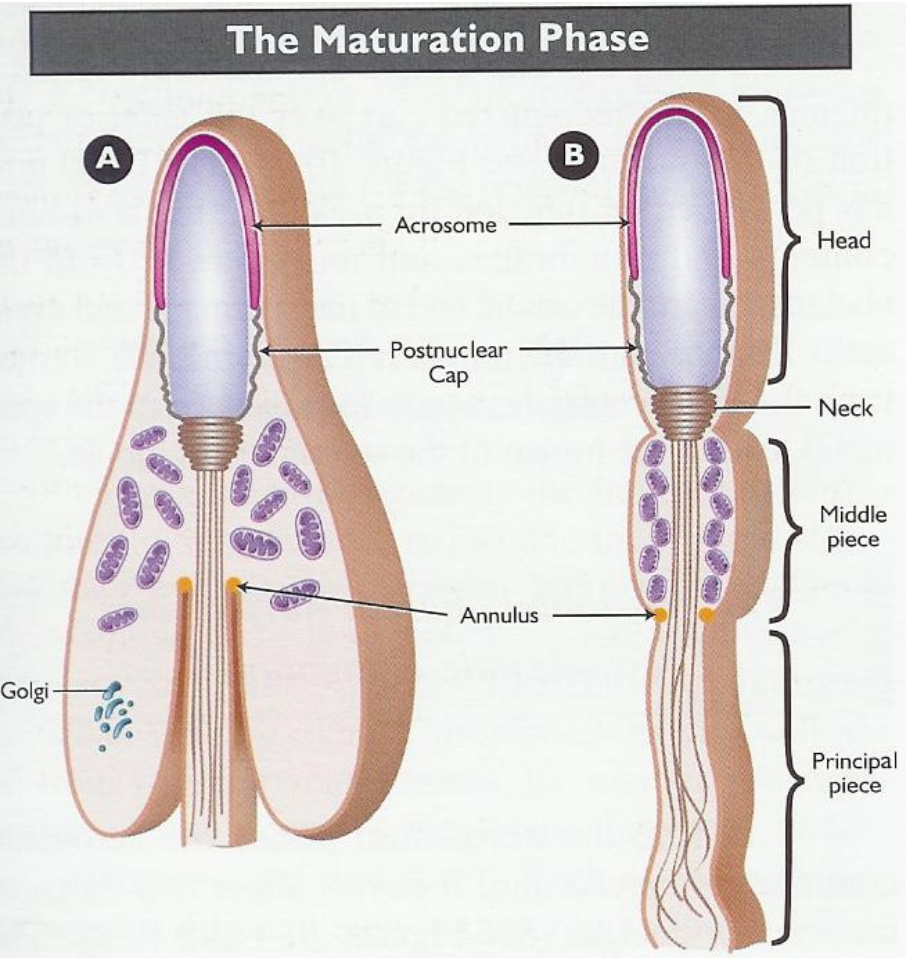


A

The spermatid nucleus begins to elongate and the acrosome eventually covers the majority of the anterior nucleus. The manchette forms in the region of the caudal half of the nucleus and extends down toward the developing flagellum.

B

The neck and the annulus are formed and the later will become the juncture between the middle piece and the principal piece. Notice that all components of the developing spermatid are completely surrounded by a plasma membrane. M = mitochondria.



A and B

Mitochondria form a spiral assembly around the flagellum that defines the middle piece. The postnuclear cap is formed from the manchette microtubules. The annulus forms the juncture between the middle piece and the principal piece.

Spermiation

- The mature spermatozoa released from the protective Sertoli cells into the lumen of the seminiferous tubule and a process called *spermiation* then takes place, which removes the remaining unnecessary cytoplasm and organelles.
- The resulting spermatozoa are now mature but lack motility, rendering them sterile. The non-motile spermatozoa are transported to the epididymis in *testicular fluid* secreted by the Sertoli cells with the aid of peristaltic contraction.
- In the epididymis they acquire motility and become capable of fertilization. However, transport of the mature spermatozoa through the remainder of the male reproductive system is achieved via muscle contraction rather than the spermatozoon's recently acquired motility.

Structure Of The Sperm

The Head

- has two important features.

1. The acrosome (derived from Golgi apparatus) contains hydrolytic enzymes which are released when the sperm reaches an ovum. These enzymes digest the outer membrane of the egg (proteins and complex sugars) , allowing penetration of the sperm.
2. The nucleus (haploid) contains a single set of chromosomes derived from the male. This will include either an 'X' or 'Y' chromosome, because of the way the XY separate during meiosis.

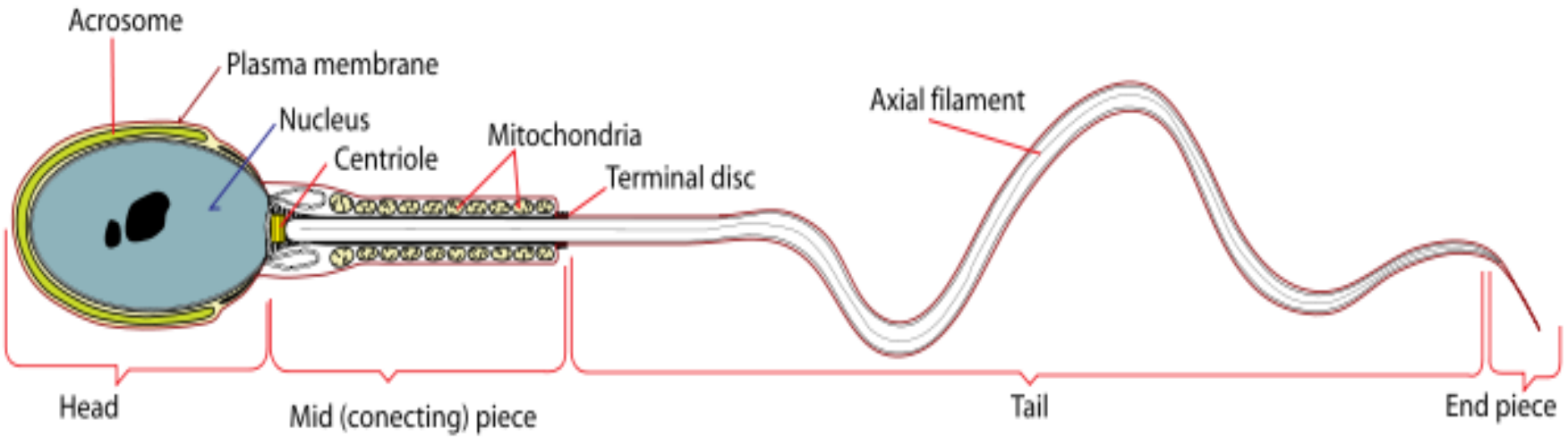
In many species, a region of globular actin molecules lies between 1&2 that used to extend a finger-like process during early stages of Fertilization.

The Middle Section

- behind the head, contains numerous mitochondria. These respire sugars in the semen to generate ATP in order to provide the energy for movement of the tail.

The Tail

- (Flagellum) contains microfilaments running the length of the tail (arranged in the usual 9 + 2 system seen in Eukaryotic organisms). Rhythmic contraction of the filaments causes the tail to wave and move against the fluid environment, providing forward motion.


Acrosome
Plasma membrane
Nucleus
Centriole
Mitochondria
Terminal disc
Axial filament
Head
Mid (conecting) piece
Tail
End piece

Abnormalities of sperms

1. Morphological Abnormalities:

- The head & tail may be abnormal, they may be:

a) giants.

b) Dwarfs.

c) Joined in head or in tail.

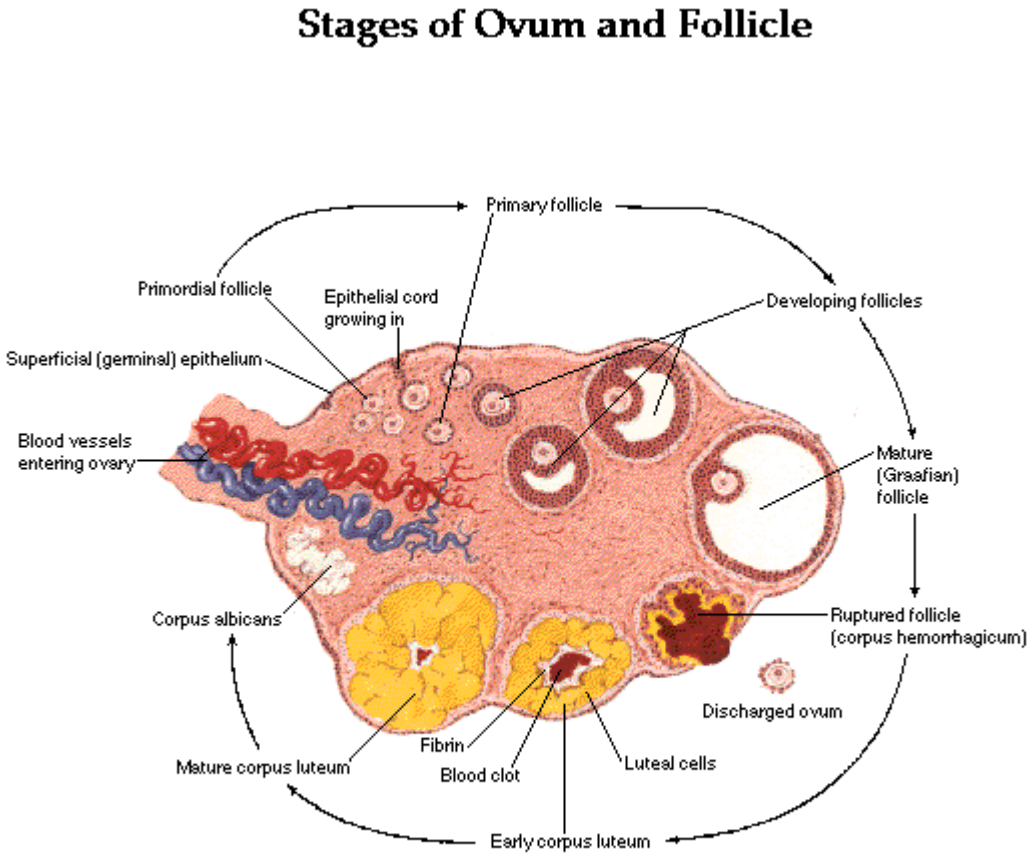
- Lack motility and don't fertilize the egg.

2. Numerical Abnormalities:

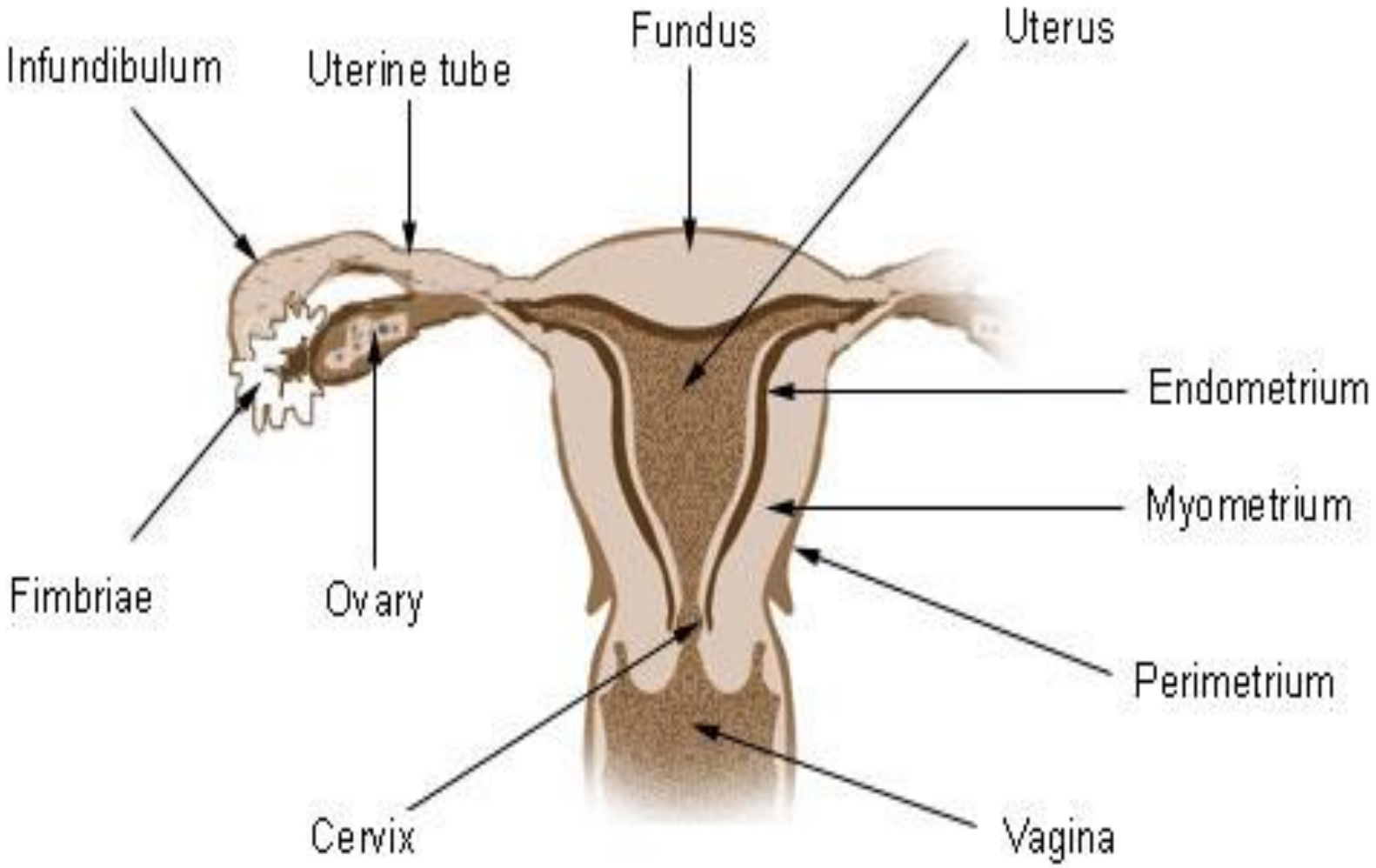
- Oligospermia: few number of sperms in semen.
- Aspermia: no sperms at all in semen.
- Necrospermia: sperms found dead.

Female Genital System

- The Ovary: female sex gland, produce ova.
- The Uterus: in which the fetus develop.



Uterus and Uterine tubes



Oogenesis

- Formation of female gametes, it means differentiation of female primordial germ cell (oogonium) into mature ovum.
- Period of multiplication : in which oogonia(2N) increased in the ovary through mitotic division.
- Period of growth : oogonia (2N) grow to primary oocytes (2N).
- Period of maturation : primary oocytes (2N) enter meioses I to produce secondary oocytes (N) & first polar body (N).
- Then, complete the second meioses to form mature ova (N) and 3 polar bodies.

Oogenesis

- A normal baby girl had about 2 million primary oocytes in her ovaries.
- By 7 years old about 300,000 remain, her body reabsorbed the rest.
- Only about 400 to 500 oocytes will be released during her reproductive years.
- Penetration of the sperm induces the secondary oocyte and the first polar body to complete meiosis II.

DIFFERENCES

SPERMATOGENESIS

- COMPLETES TWO MEIOTIC DIVISIONS
- CREATES FOUR EQUAL HAPLOID SPERMS

OOGENESIS

- STOPS AT PROPHASE OF THE MEIOTIC DIVISION UNTIL OVULATION,
- AT THE TIME OF OVULATION, THE OOCYTE GOES TO METAPHASE OF SECOND MEIOSIS.
- IF NOT FERTLIZED, EGG DEGENERATES
- CREATES 1 OOCYTE AND 3 POLAR BODIES

Thank you

Questions?